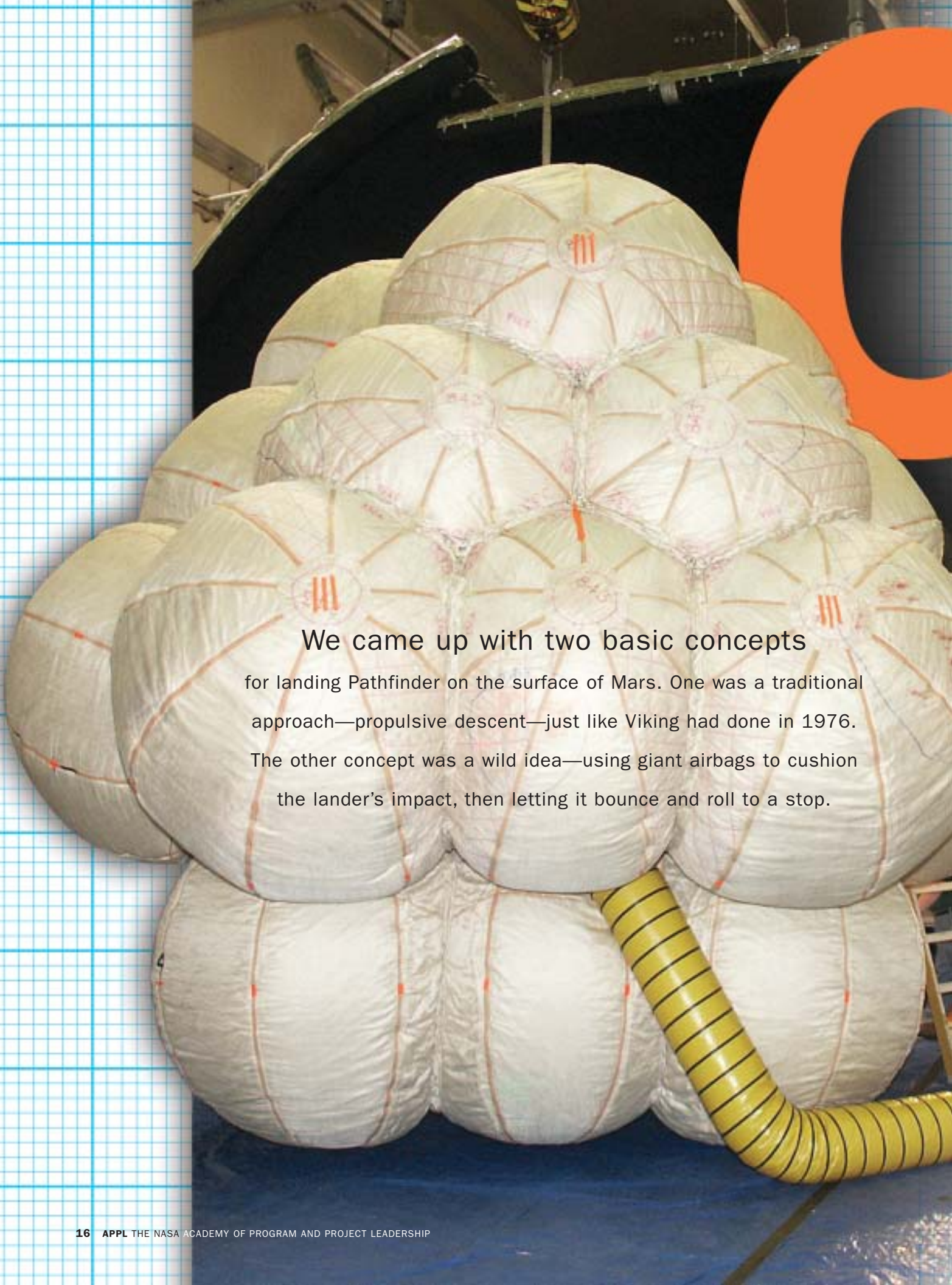

We came up with two basic concepts

for landing Pathfinder on the surface of Mars. One was a traditional approach—propulsive descent—just like Viking had done in 1976. The other concept was a wild idea—using giant airbags to cushion the lander's impact, then letting it bounce and roll to a stop.

OFF THE CHARTS

by Brian K. Muirhead

NASA BASICALLY LOOKED AT THE TWO OPTIONS AND SAID, "Well, propulsion...that's the old way of doing business. You guys will never get this job done if you do it that way. It's too expensive." And so we said, "Okay, let's go make this airbag thing work."

The airbags idea was clearly eccentric. Off the charts. When you think of an airbag, you think of the automobile design, about twice the size of a pillow, which took many years to develop. But what we needed would have to be about 19 feet in diameter, designed to tolerate a head-on collision with a very rocky Mars surface at 60 miles per hour or more. And not just once, but multiple times, as it bounced and rolled to a stop. The only thing in common between our design and an automobile airbag was the name. Another very eccentric aspect of this was the idea of using fabrics in outer space. We were used to dealing in aluminum and titanium, but this needed to be the stuff of bulletproof vests... advanced polymer cloth. We'd worked with software in space, but not "softgoods."

The young man who had come up with the kernel of the airbag concept was Tomasso Rivellini. Tom had never done a flight hardware engineering job before, but he had the right energy and creative instincts. So we gave him the job. Of course, he knew he needed help. He went to Bob Bamford and Bill Layman, two of JPL's intellectual giants, for help in developing the basic design. But once Tom started working the details, he alone was responsible for figuring out a way to build and test this behemoth. Tom knew that JPL didn't have the expertise in working with fabrics and sewing—with so-called "softgoods." So he sought out and found people at Sandia National Laboratory in Albuquerque and ILC Dover in Dover, Delaware, to help build a scale model followed by full-scale prototypes. This job took a lot of trial and error. Tom started with a 1/20th scale model, and worked up to full scale. It turned out that the only way to really understand how an airbag works is to test it full scale.

Every time we showed the video of the first full-scale test, in which the airbags were dropped about 120 feet onto a flat surface, people laughed. It did look comical seeing a giant beachball bounce like a superball. But our early attempts were discouraging. Our first drops on a rocky surface simulating expected Martian terrain were complete failures. We weren't sure if this thing was going to work. But we kept working the details, improving the design, and going back into test. It was a very iterative process. We tried an analytical approach, but we spent over a week of Cray computer time to get only a few seconds of data on the impact. The problem was just too complex for state-of-the-art analysis tools at that time. So we had to rely on Tom and his team's ability to design, build, and test their way to a design that would work. And they did.

The manager of NASA's Viking mission to Mars—the legendary Jim Martin—was, at best, skeptical that the airbag idea would work. He chaired the formal review boards that oversaw the project's progress throughout its three-year development. He knew about all the trials and tribulations of the airbag development, and that the proof would only come on landing day. On July 4th, 1997, Jim and I were standing next to each other shortly after the landing. Jim turned to me and said, "You know, Brian, I think these airbags ought to be the required technology, the technology of choice, for any mission that is going to land where the terrain is unknown." Our eccentric idea had just become mainstream. •

"I like to do things that people consider impossible missions," says **BRIAN K. MUIRHEAD**, who led the design, development, and launch of the flight system for the Pathfinder Mission to Mars. "There were many people who thought we would not be able to land on Mars. [This mission] attracted innovators and some renegades. It was a major challenge, so it hooked the risk-takers and people with a competitive spirit." For his achievements on Pathfinder, Muirhead was awarded NASA's Outstanding Leadership medal. He was also named Engineer of the Year for 1997 by *Design News* and 1997 Laureate for Space by *Aviation Week & Space Technology*. In 1998, he achieved another milestone of sorts, when he was awarded his very own "star" in the sky. Asteroid Muirhead is a Mars-crossing asteroid, between 5 and 9 kilometers (about 3 to 6 miles) in diameter, and reported to be traveling in a highly inclined, eccentric orbit.